FIG.1

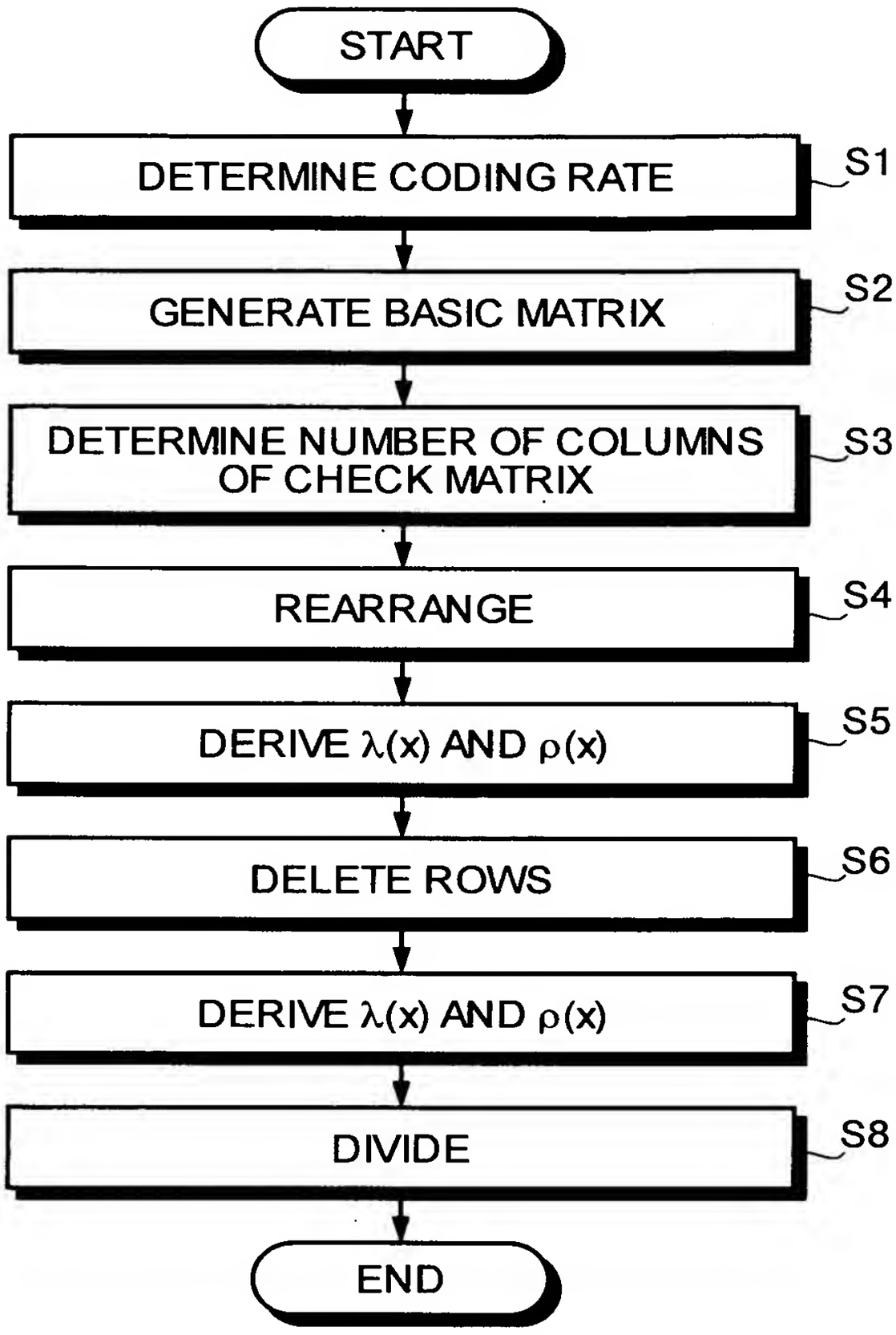

START
DETERMINE CODING RATE
S1
GENERATE BASIC MATRIX
S2
DETERMINE NUMBER OF COLUMNS OF CHECK MATRIX
S3
REARRANGE
S4
DERIVE λ(x) AND ρ(x)
S5
DELETE ROWS
S6
DERIVE λ(x) AND ρ(x)
S7
DIVIDE
S8
END

FIG.2

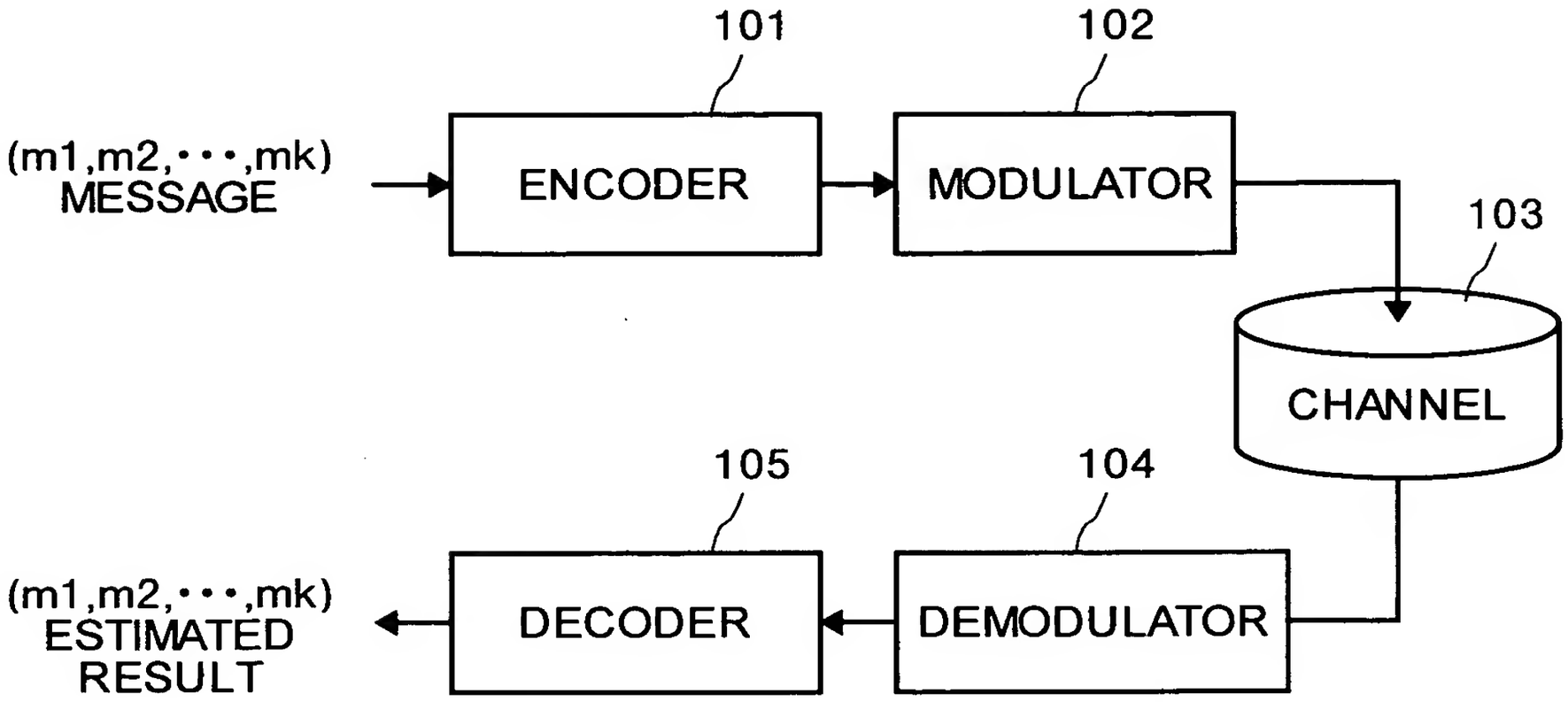

101
102
(m1,m2,・・・,mk)
MESSAGE
ENCODER
MODULATOR
103
CHANNEL
105
104
(m1,m2,・・・,mk)
ESTIMATED
RESULT
DECODER
DEMODULATOR

FIG.3

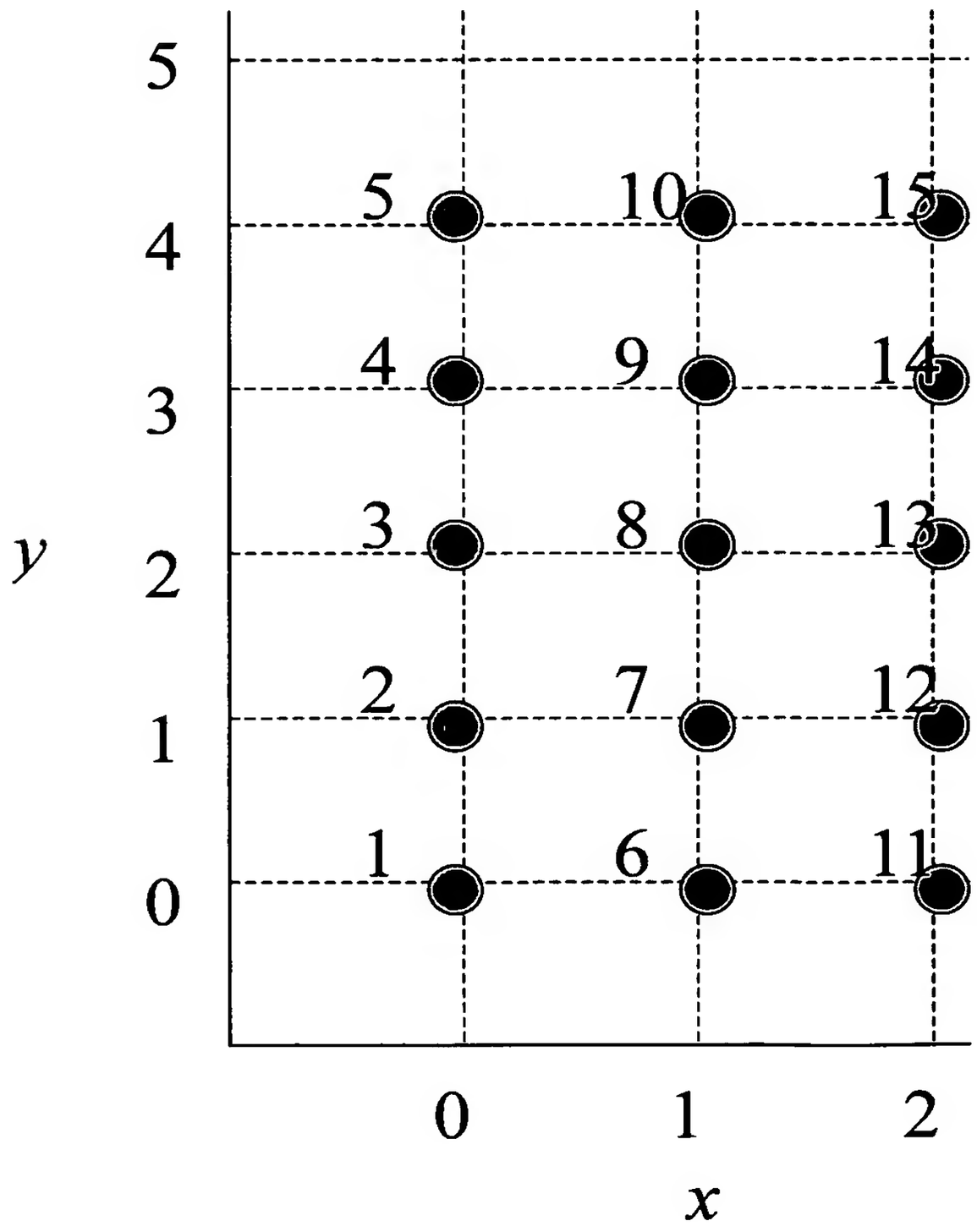

5
4
3
2
1
0
y
5
10
15
4
9
14
3
8
13
2
7
12
1
6
11
0
1
2
x

FIG.4

	s=0	s=1	s=2	s=3	s=4
CLASS	{1,6,11}	{1,7,13}	{1,8,15}	{1,9,12}	{1,10,14}
	{2,7,12}	{2,8,14}	{2,9,11}	{2,10,13}	{2,6,15}
	{3,8,13}	{3,9,15}	{3,10,12}	{3,6,14}	{3,7,11}
	{4,9,14}	{4,10,11}	{4,6,13}	{4,7,15}	{4,8,12}
BLOCK	{5,10,15}	{5,6,12}	{5,7,14}	{5,8,11}	{5,9,13}

FIG.5

s=0, S={s}, B'=$B(s)$, S'={1,2,...,m-1}.
While $S'\neq$empty set
s=s+1
 if g(V,$B'\cup B(s)$)=8
  S=$S\cup$ {s}
  S'=$S'\setminus$ {s}
  B'=$B'\cup B(s)$
 else
  S'=$S'\setminus$ {s}
 end
end

FIG.6

k	m	S	N=|B|	M=|V|	(dv,dc)
3	5	0,1	10	15	(3,2)

FIG.7

$$
\begin{array}{c}
p_1 \\ p_2 \\ p_3 \\ p_4 \\ p_5 \\ p_6 \\ p_7 \\ p_8 \\ p_9 \\ p_{10} \\ p_{11} \\ p_{12} \\ p_{13} \\ p_{14} \\ p_{15}
\end{array}
\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0
\end{pmatrix}
$$

FIG.8

k	*m*	*S*	*N*=|*B*|	*M*=|*V*|	*(dv,dc)*
10	*353*	*0,1,10,11,23,24,224*	*2471*	*3530*	*(10,7)*

FIG.9

for $i = 1$ to $|\mathbf{V}|$

$$R_{k*((i-1) \bmod m)+\lfloor (i-1)/m \rfloor+1} = R_i$$

end

FIG.10

$$\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0
\end{pmatrix}$$

FIG.11

Rate	0.5		
	x	λx	No.
	2	0.28647619	3008
	3	0.264571429	1852
	4	0.001142857	6
	6	0.138285714	484
	10	0.30952381	650
	x	ρx	No.
	7	1	3000
σGA			0.940358043

FIG.12

	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													

G0	2																													
	j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
C(1)	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
C(2)	2	LB$_i$(1)	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
C(3)	4	LB$_i$(2)	6	9	12	15	18	20	23	27	30	32	29	26	24	21	19	16	13	10	8	5	2	31	28	25	22	20	17	14	11	9	6
C(4)	8	LB$_i$(3)	9	12	16	20	24	27	32	29	26	23	18	15	12	8	5	2	31	28	25	22	19	16	13	10	7	4	1	30	27	24	21
C(5)	16	LB$_i$(4)	12	16	20	25	30	3	1	6	11	15	20	23	27	32	29	26	22	19	16	13	10	7	4	1	30	28	25	22	19	17	14
C(6)	32	LB$_i$(5)	15	20	25	30	3	6	11	14	19	23	28	31	2	7	10	13	17	21	24	27	32	29	26	22	20	17	14	11	8	5	2
C(7)	27	LB$_i$(6)	18	24	32	29	26	23	19	16	13	10	7	4	1	30	27	24	21	17	14	11	8	5	2	31	28	25	22	19	16	13	10
C(8)	17	LB$_i$(7)	21	28	27	24	22	18	15	12	9	6	3	1	30	27	25	21	18	15	12	9	6	3	1	29	26	23	20	17	14	11	8
C(9)	31	LB$_i$(8)	24	27	31	28	25	22	18	15	12	9	6	3	1	29	26	23	20	16	13	10	7	4	2	31	28	25	22	19	16	13	10
C(10)	25	LB$_i$(9)	27	31	28	25	23	19	16	13	10	7	4	2	31	28	26	22	19	16	13	10	7	5	2	31	28	25	22	19	16	13	11
C(11)	13	LB$_i$(10)	30	3	1	29	26	23	20	17	14	11	8	6	3	1	29	26	23	20	17	14	11	8	5	2	31	28	25	22	19	16	13
C(12)	26	LB$_i$(11)	2	5	3	30	27	24	21	18	15	12	9	7	4	2	31	28	25	22	19	16	13	10	8	5	2	31	28	25	22	19	16
C(13)	15	LB$_i$(12)	4	7	5	2	31	28	25	22	19	16	13	11	8	6	3	1	29	26	23	20	17	14	12	9	6	3	1	29	26	23	20
C(14)	30	LB$_i$(13)	7	9	6	3	1	29	26	23	20	17	14	12	9	7	4	2	31	28	25	22	19	17	14	11	9	6	4	1	30	27	24
C(15)	23	LB$_i$(14)	8	10	7	4	2	31	28	25	22	19	17	14	11	9	6	4	1	30	27	24	21	18	15	12	10	7	5	2	31	28	25
C(16)	9	LB$_i$(15)	10	12	9	6	4	1	30	27	24	21	18	16	13	10	8	5	2	31	28	25	22	20	17	14	11	8	6	3	1	29	26
C(17)	18	LB$_i$(16)	11	13	10	8	5	2	31	28	25	23	20	17	15	12	9	7	4	2	31	28	26	23	21	18	15	12	9	7	4	2	29
C(18)	29	LB$_i$(17)	13	15	12	9	7	4	2	31	28	26	23	21	18	15	13	10	8	5	3	1	29	26	24	21	18	15	13	10	8	5	3
C(19)	21	LB$_i$(18)	14	16	13	11	8	5	3	1	29	27	24	22	19	16	14	11	9	6	4	2	31	28	25	23	20	17	14	12	9	6	4
C(20)	5	LB$_i$(19)	15	18	14	12	9	6	4	2	31	29	26	24	21	17	15	12	10	7	5	3	1	29	27	24	21	18	16	13	10	8	5
C(21)	10	LB$_i$(20)	17	19	16	14	11	8	6	3	1	30	27	25	22	19	17	14	12	9	7	4	2	31	29	26	23	20	18	15	12	9	7
C(22)	20	LB$_i$(21)	18	20	17	15	12	9	7	4	2	31	28	26	23	20	18	15	13	10	8	5	3	1	30	27	24	21	19	16	13	11	8
C(23)	3	LB$_i$(22)	20	23	19	17	14	11	9	6	4	2	31	29	26	23	21	18	16	13	11	8	6	3	1	30	27	25	22	19	17	14	11
C(24)	6	LB$_i$(23)	23	26	22	20	17	14	12	9	7	4	2	32	29	26	24	21	19	16	14	11	9	6	4	1	31	28	26	23	20	18	15
C(25)	12	LB$_i$(24)	24	28	25	23	20	17	15	12	10	7	5	2	32	29	27	24	22	19	17	14	12	9	7	4	2	31	29	26	23	21	18
C(26)	24	LB$_i$(25)	25	29	26	24	21	18	16	13	11	8	6	3	1	30	28	25	23	20	18	15	13	10	8	5	3	1	30	27	24	22	19
C(27)	11	LB$_i$(26)	26	30	27	25	22	19	17	14	12	9	7	4	2	31	29	26	24	21	19	16	14	11	9	6	4	2	31	28	25	23	20
C(28)	22	LB$_i$(27)	27	31	28	26	23	20	18	15	13	10	8	5	3	1	30	27	25	22	20	17	15	12	10	7	5	3	1	29	26	24	21
C(29)	7	LB$_i$(28)	28	32	29	27	24	21	19	16	14	11	9	6	4	2	31	28	26	23	21	18	16	13	11	8	6	4	2	30	27	25	22
C(30)	14	LB$_i$(29)	29	1	30	28	25	22	20	17	15	12	10	7	5	3	1	29	27	24	22	19	17	14	12	9	7	5	3	1	28	26	23
C(31)	28	LB$_i$(30)	30	2	31	29	26	24	22	19	17	15	13	11	9	7	5	4	2	31	29	27	25	23	21	19	17	15	13	11	9	7	5
C(32)	19	LB$_i$(31)	31	4	2	32	30	27	25	23	21	18	16	14	12	10	8	6	4	32	30	28	26	24	22	20	18	16	14	12	10	8	6
		LB$_i$(32)	32	5	3	31	29	28	26	24	22	20	18	17	15	13	11	9	7	5	3	32	31	29	28	26	24	22	20	18	17	15	14

permutation pattern of basic random sequence

Basic Random sequence

FIG.13

q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
$L_{iq}(1)$	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9
$L_{iq}(2)$	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10
$L_{iq}(3)$	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16
$L_{iq}(4)$	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24
$L_{iq}(5)$	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25
$L_{iq}(6)$	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28
$L_{iq}(7)$	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23
$L_{iq}(8)$	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5
$L_{iq}(9)$	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8
$L_{iq}(10)$	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12
$L_{iq}(11)$	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31
$L_{iq}(12)$	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14
$L_{iq}(13)$	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30
$L_{iq}(14)$	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21
$L_{iq}(15)$	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4
$L_{iq}(16)$	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6
$L_{iq}(17)$	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17
$L_{iq}(18)$	15	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7
$L_{iq}(19)$	29	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15
$L_{iq}(20)$	2	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29
$L_{iq}(21)$	3	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2
$L_{iq}(22)$	27	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3
$L_{iq}(23)$	22	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27
$L_{iq}(24)$	26	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22
$L_{iq}(25)$	18	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26
$L_{iq}(26)$	1	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18
$L_{iq}(27)$	20	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1
$L_{iq}(28)$	32	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20
$L_{iq}(29)$	11	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32
$L_{iq}(30)$	13	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11
$L_{iq}(31)$	19	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13
$L_{iq}(32)$	9	10	16	24	25	28	23	5	8	12	31	14	30	21	4	6	17	7	15	29	2	3	27	22	26	18	1	20	32	11	13	19

FIG.14

FIG.15

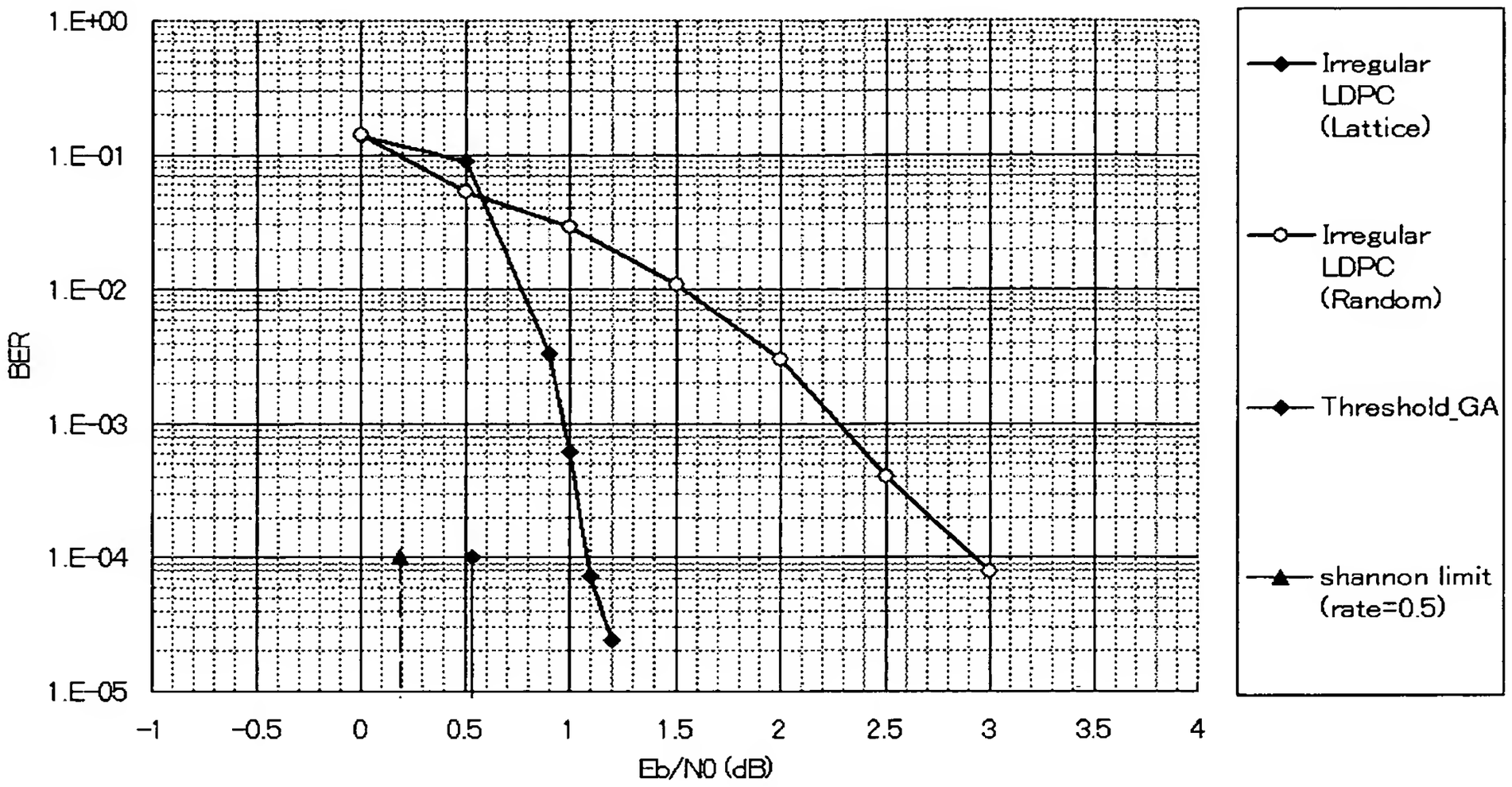

1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
BER
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
Eb/N0 (dB)
Irregular LDPC (Lattice)
Irregular LDPC (Random)
Threshold_GA
shannon limit (rate=0.5)

FIG.16

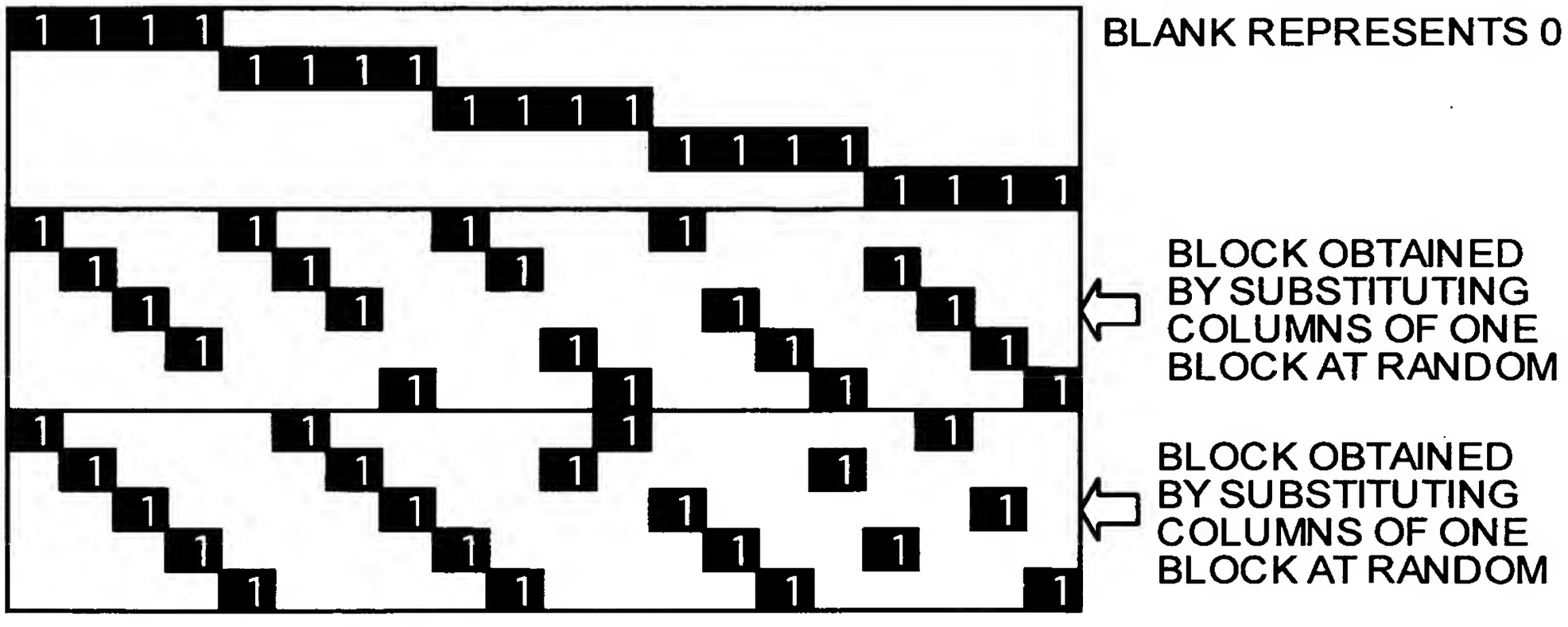
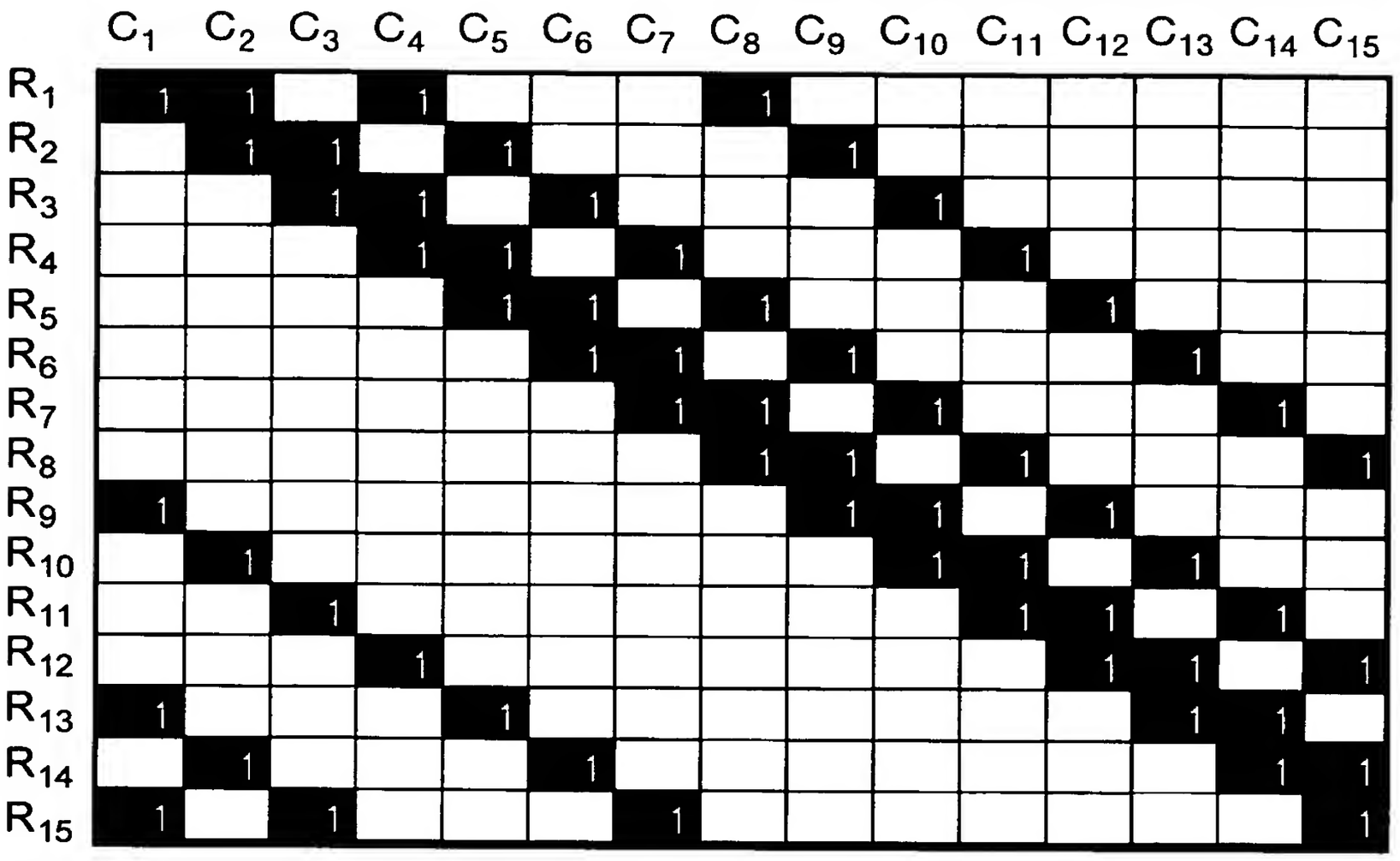

BLANK REPRESENTS 0
BLOCK OBTAINED BY SUBSTITUTING COLUMNS OF ONE BLOCK AT RANDOM
BLOCK OBTAINED BY SUBSTITUTING COLUMNS OF ONE BLOCK AT RANDOM

FIG.17


C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15

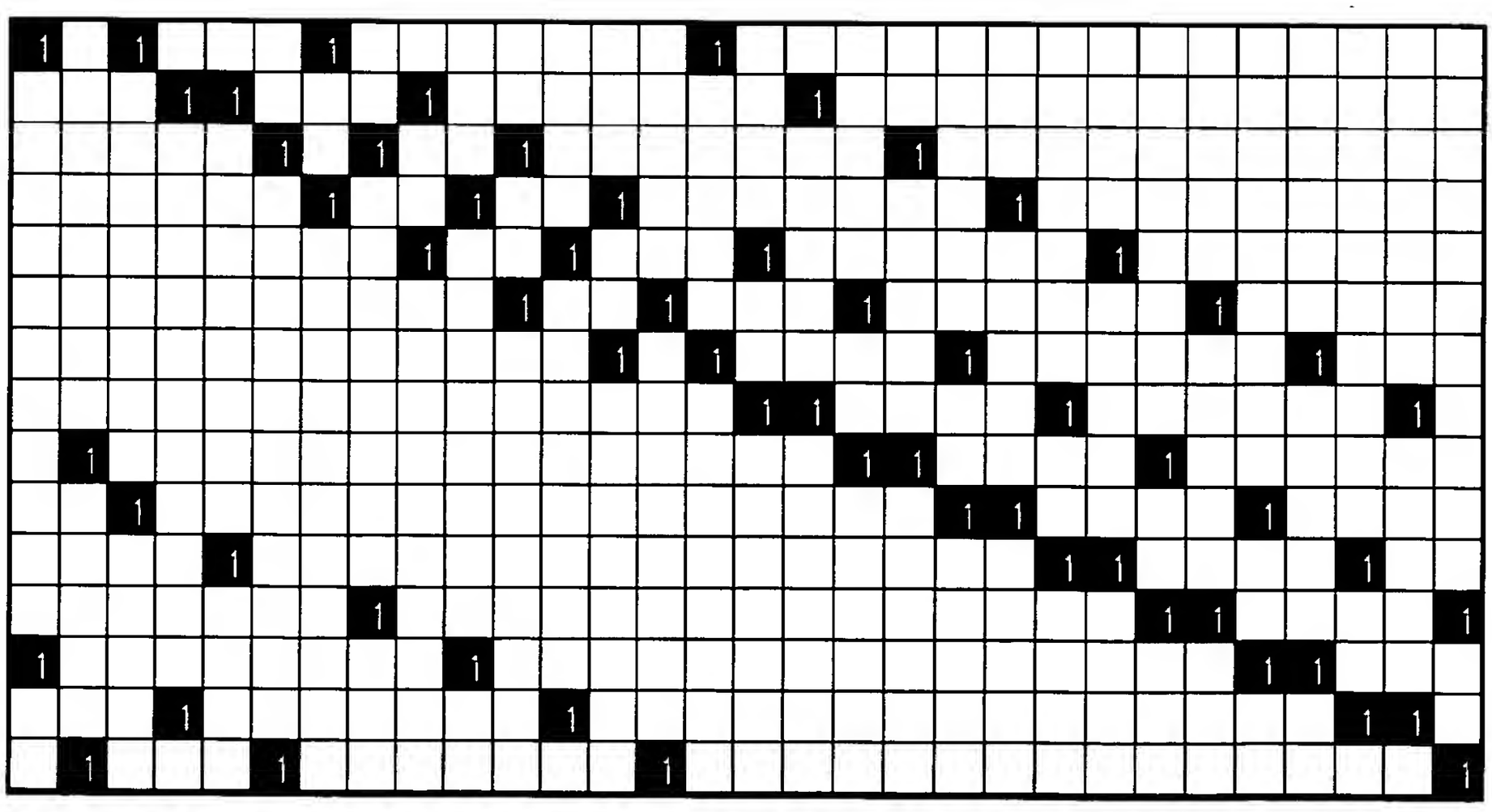



FIG.18